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THE STATE OF WAR.

PRIOR to the outbreak of war on September 3, 1939, very large numbers of the members of the Institution were already engaged on work directly or indirectly related to the national defence programme of the Government. The proportion of members so engaged will now be greatly increased.

It is the wish of the Council, which met at London on September 15, under the chairmanship of Lord Sempill (*Deputy-President*), that the Institution should continue to function actively in the national interest.

Headquarters will remain in London. Publications will be maintained. The Research Department will carry on. Committee work will not be interrupted. At least some lecture meetings will be held.

The most urgent task for the Institution arising out of the state of war is in connection with the operation of the Central Register of the Ministry of National Service and Labour.

Several points of policy in that connection have already arisen regarding which Local Section Committees and Affiliated Firms have been consulted. Many hundreds of members of the Institution are on the register. It is of the first importance that its operation should be made as efficient as possible. For this and other purposes it is intended to make the fullest use of the territorial organisation of the Institution. Our twenty Local Section Committees will be prepared to function actively, both in an advisory and an executive capacity, as and when required.

This Institution was founded in 1921 largely because of the chaos on the production side in the war of 1914-18 which its founder members had to face and help to overcome.

Things are different to-day, thanks largely to the emergence of Production Engineers as key men in the workshops of our engineering industries.

(*Vol. XVIII, No. 9, September, 1939*).

During the war immense responsibilities must rest upon Production Engineers. Problems are bound to arise in connection with which their collective judgment may be of high value to the nation. It will be for this Institution to see to it, when necessary, that their collective judgment does not go unheard in the councils of authority.

It may not always be possible to communicate at once to all members information which they ought to have without delay. To meet such a contingency a pocket booklet is being prepared for distribution giving the names of the members of our Local Section Committees, more than 250 in number, together with their addresses and telephone numbers.

Reference should be made to members on this list, when necessary, both for the receipt and the transmission of information.

ELECTROLYTIC PROCESSES FOR METAL FINISHING

Paper presented to the Institution, Coventry Section, by E. J. Dobbs.

Anodic Oxidation of Aluminium.

IT is now generally accepted that the corrosion resistance of most metals is provided by the film of oxide on the surface. This film of oxide in the case of the noble metals is imperceptible, but still always present, but in the case of the less noble metals it is easily apparent. Much research work has been done during the past twenty years to discover a means of treatment whereby this oxide film can be produced at will and in any desired thickness, many times greater than the naturally occurring film. Most of this research has been directed to augmenting the natural oxide film on aluminium and the result has been the adoption of solutions now in general use for the anodic production of oxide films on the surface of aluminium.

The processes employing these solutions may be classified generally under three headings, viz. : (1) Bengough Stuart or Chromic Acid process ; (2) The sulphuric acid ; (3) The Oxalic acid process.

The third process is so very little used in this country that the talk will be confined to a consideration of the first two processes.

The Bengough Stuart Process

This was discovered by Dr. G. D. Bengough and Mr. J. M. Stuart in 1924 and is fully described in the Journal of the Department of Scientific and Industrial Research, 1926. It employs a solution of chromic acid of a strength of 3%, making the aluminium article the anode in the electrical circuit and using stainless steel cathodes.

The solution is contained in a plain iron tank and is maintained at a temperature of 40°C. ± 1°C., gentle agitation being used to keep as near as possible a constant temperature at the cathode face and prevent local overheating.

A pressure of 40 volts is gradually applied ; starting from zero the time required to reach 40 volts should be at least fifteen minutes, in steps of 2 to 3 volts or so every minute. This necessitates a finely controlled resistance in th field of the 60 volt dynamo and effectively prevents any sudden surge of current before the film has had time

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Coventry, February 21, 1939.

to build up. Should too much current be applied suddenly, a rupture of the film will occur, and it will be attacked chemically by the acid solution. The voltage is kept constant at 40 volts for thirty-five minutes, then slowly raised to 50 volts in the succeeding five minutes and maintained at this voltage for a further five minutes, making an hour's treatment in all. The current density employed will be approximately three amperes per square foot for aluminium, and four to five amperes per square foot for duralumin, but for alloys of varying composition the amperage may go as high as 30 amperes per square foot for a considerable time until the alloying elements in the surface have been dissolved away, when the current density will fall considerably, but never so low as that experienced with pure aluminium.

It is for this reason that the general conditions governing the working of the solution should be modified when treating aluminium alloys. The best modification has been reduction of temperature of solution. This allows for the maximum voltage to be employed with a considerable reduction in the current density used, so that the film is progressively built up without elimination of the alloying metals and constant breakdown of the film in the solution.

A reduction of temperature of the solution from 40°C. to 25°C. allows for the use of less than half the current density when using a pressure of 40 volts, and the film so produced has a much better appearance than that produced at 40°C. with the same pressure.

Method Procedure.

The articles to be anodically oxidised or "anodised" in the popular phrase, must be suspended in the solution by aluminium wire or duralumin rod, making contact on the anode rod, and these wires or rods must be cleaned after each load, to remove the oxide film from their surface, so that true metal to metal contact is established.

All grease must be removed from the surface of the pieces being anodised by the usual methods of removing grease as practised in electroplating generally, but caustic cleaners of any kind are entirely unsuitable owing to their solvent action on the metal.

The cleaned articles hung in the bath and the slinging wires or rods making firm contact with the anode rod, the current is gradually applied in as equal steps as possible so that in fifteen minutes a pressure of 40 volts is reached without any sudden or violent jump occurring in the amperage used.

At the end of the hour the current is shut off and the articles are removed from the vat, well swilled in clean cold running water and dried. Aircraft parts are dipped in a solution of lanoline in benzol, or in the newer method of treatment a solution of aluminium stearate in benzol is used. (2%).

In the case of castings of which the metal may be very porous it is good practice after swilling and drying to soak in a solution of $2\frac{1}{2}\%$ oxalic acid for a few minutes so that any chromic acid left in the pores of the metal and not removable by swilling, can be destroyed.

Solution.

The chromic acid solution is constantly deteriorating in use through the reduction of it by the hydrogen at the cathode, with the formation of chromium chromate and the neutralisation of the chromic acid by the aluminium that dissolves in it, so that frequent periodical testing is necessary to maintain the *free* chromic acid present, and it is now becoming a general practice to discard the solution after three additions of chromic acid have become exhausted.

The film produced is mainly aluminium oxide of a thickness of .00012 in. to .00015 in., and has the faculty of forming a lake or insoluble metal organic salt with dyestuffs of the alizarine series. It has a high electrical resistance and will often withstand a spark test of 200 volts and over.

The Sulphuric Acid Process

The process employs a solution of sulphuric acid as the electrolyte, the strength of acid varying for the type of film required, whether hard or soft, but the usual strength is 20 to 25%.

It is contained in a lead-lined vat, the vat lining being made the cathode, and the solution is maintained at a temperature of about 21° to 24°C.

The pressure used is generally about 12 to 14 volts and the current density is approximately 14 amperes per square foot for aluminium with 16 amperes per square foot for duralumin. The time of treatment is thirty minutes.

The temperature control of this solution is most important, as any great rise of temperature results in considerable dissolution of the aluminium. Even under the best of operating conditions the amount of dissolved aluminium is at least 20 times that occurring with the chromic acid process. The general procedure for working the solution is the same, but there is a considerable difference in the appearance of the film. The oxide coating from the sulphuric acid process is clear and translucent and forms a clear, bright colour with the dyestuff, whereas the film from the Bengough Stuart process is more glassy and opaque, and with any colour of dyestuff used it gives a pastel shade.

Comparison of the Two Processes

From the standpoint of corrosion resistance of the film, when measured from the aircraft point of view, the Bengough Stuart

process affords the better protection, and in the case of aircraft components having riveted joints the advantages of this process are more marked.

If any chromic acid should be left in the joints, this will not harm or weaken the structure, whereas sulphuric acid left in the joints can set up serious corrosion by simple chemical attack on the aluminium.

These points are strongly emphasised in a recent paper by J. W. W. Willstrop and Dr. H. Sutton, entitled " Anodic Films on Aluminium and its alloys for protection against corrosion " and read before the Electrodepositors' Technical Society on February 8, 1939. A very interesting comparison is given between the chromic acid, sulphuric acid, and oxalic acid processes and the protective values of the films produced from them.

The Chromating of Magnesium and its Alloys.

The increasing use of magnesium and its alloys in aircraft construction due to the extreme lightness of the metal combined with its exceptional strength, has necessitated considerable research in methods of protection against corrosion. Magnesium is exceptionally prone to continuous oxidation unless protected, especially against saline corrosion, which is met so frequently with aircraft parts, and the treatment successfully used involves the production of: (*a*) A chromate film on the surface—" Chromating "; (*b*) a selenium coating.

The Chromating Process.

There are two different solutions employed in the chromate treatment of magnesium alloys, both developed at the Royal Aircraft Establishment, Farnborough, by H. Sutton and L. F. le Brocq. The first solution involves a treatment time of six hours, whereas the second solution calls for a thirty minutes' immersion. Both solutions are used boiling.

The treatment of the alloys as laid down by the Air Ministry is as follows:—

(*a*) For parts which are not machined to very fine tolerances dip for fifteen seconds in 10% nitric acid and examine. Repeat until the surface appears uniformly clean. Wash in cold water.

(*b*) For parts which have been machined to very fine tolerances immerse for thirty minutes in a boiling 2% caustic soda solution, or alternatively in a 5% aqueous solution of " Zonax " metal cleaner, the bath being kept near the boiling point. Wash in cold water.

(*c*) For castings which are to be partly machined to very fine tolerances clean in the nitric acid bath as at (*a*) above, wash with hot water, machine to size, and immerse for thirty minutes in a boiling 2% caustic soda solution, or alternatively in a 5% aqueous

solution of " Zonac " metal cleaner, the bath being kept near the boiling point. Wash in cold water.

A solution containing: 1.5% potassium dichromate, 1.0% potassium alum, 0.5% caustic soda is required. This is prepared by making a mixed solution of high concentration of alum and caustic soda, and adding thereto the dichromate in the form also of a strong solution. The degree of concentration of the solutions employed should be such that when the mixture is diluted with water, the requisite strength is obtained. The final solution is heated to 100°C. and the parts immersed for six hours and gently boiled. The parts should then be washed and dried. Evaporation losses should be made good from time to time.

The solution for the shorter process contains: Ammonium sulphate 3%, potassium dichromate 1.5%, ammonium dichromate 1.5%, ammonia .880, 0.5%.

The parts to be protected are treated exactly as described before, and are immersed in this solution for thirty minutes, the solution boiling briskly the whole time. They are then taken out, swilled in hot water and dried. The bath maintains its efficiency for long periods, but requires occasional small additions of chromic acid to correct the alkalinity produced by the slight dissolution of magnesium.

These treatments produce a pleasing brown to black film on the surface, which is lustrous in the case of polished parts but dead matt in the case of castings.

The Selenium Treatment.

The principle of this treatment involves the production of a film of amorphous selenium on the surface of the magnesium alloy by immersion in a solution of selenious acid or an acid solution of a selenite. It is analagous to immersion tinning, silvering or gilding and consists of a base exchange. A slight amount of magnesium dissolves in the solution, and by the battery produced a molecular equivalent of selenium is deposited.

The film of selenium is reddish brown and makes an excellent base for the reception of a coating of paint. The type of paint recommended is the zinc chromate—tung oil paint, followed by a cellulose coating pigmented with aluminium leaf.

Hard Chrome Plating.

You are all, no doubt, familiar with chromium plating as a decorative finish as applied to cars and a multitude of other articles, but there is another aspect of chrome plating, less well known than the familiar decorative finish—the application of hard and relatively thick deposits to steel tools, and surfaces subject to abrasion. When first tried out some years ago on machine tools, early reports

regarding its value appeared to be somewhat conflicting, but in such cases investigation generally proved that the conditions to which the parts had been subjected were widely different. For instance, with punches it was found that the life of these tools and dies had been increased enormously in one case, whereas in another, failure occurred almost immediately. In the former case the tools had been used for drawing copper tubes and in the second instance for blanking stainless steel. If it is remembered that a hard chrome deposit may be not only extremely hard but also brittle, then it will be understood that treated articles will stand up well to abrasion but may fail under a sudden blow owing to fracture and flaking of the deposit.

As a general rule it may be accepted that hard chrome deposits should not be applied to parts subject to shock, but may be used with every success on articles subject to abrasive wear. Among the many different articles now being commercially treated are plug gauges, crankshafts, valve stems, drawing dies, aero-engine cylinders, printing plates and rollers, also moulds for bakelite and similar plastics. Files and drills are being plated, and it is claimed that these do not become fouled as readily as untreated steel, although, curiously enough, with twist drills it is customary to grind off the deposit from the cutting point before use.

Regarding the technique of hard chrome deposition, the vat and general equipment necessary are similar to that employed for the ordinary decorative plating, but the solution is modified to meet the different requirements and is worked at a higher temperature and current density. The influence of increased temperature and current is clearly illustrated by the following figures obtained on testing two small pieces of steel bar which had been plated in the same solution but under different conditions.

The sample treated at a temperature of 80°F. with a current density of 1 ampere per sq. in. had a surface hardness of 710, whereas that plated at 110°F. with a current density of 1½ amperes per sq. in. showed a hardness of 1,280. The tests were made with a special light load apparatus using a diamond pyramid indenting tool.

The chromic acid content of solutions for hard chrome deposition may vary between 250 and 400 grammes per litre ; the baths are generally maintained at a temperature of 110 to 120°F. (43 to 49°C.) and worked at a current density of 200 to 300 amperes per sq. ft. Deposits of several thousandths of an inch are common, whereas decorative coatings rarely exceed a thickness of 0.00005 in. Under the conditions stated the thickness of deposit obtained in one hour is about one half-thousandth of an inch.

The chromium should preferably be plated on to a hard foundation, as satisfactory results cannot be expected if the base metal is liable to distortion when the articles are put into service. In the

case of tools and steel work generally, hard chrome is deposited directly without any intervening coating, but cast-iron is sometimes nickelled first, more particularly if it is of an open texture.

Tube-drawing dies and also cylinders are mounted on a jig employing a central rod anode which must be carefully aligned so that it is equidistant at all points from the walls of the article. This is important to ensure a uniform thickness of deposit. Similarly, in the case of moulds for bakelite and plastics, especially if deeply recessed and of intricate design, then the anode must conform accurately to the contour of the mould. With the cases just mentioned, and in many other instances, only the specially shaped anodes are employed, since it is only specific parts of the work that require plating, and little useful purpose is served by keeping the ordinary flat anodes in the vat and so depositing chromium on the external faces. With crankshafts it is customary to use anodes in the shape of a ring formed from strip lead surrounding the bearing faces and held rigidly in position by means of a jig.

Those areas of the work on which no deposit is required are stopped off with a chlorinated naphthalene wax or a chemically resistant lacquer. Flat printing dies or plates are usually framed with a wire guard to prevent undue building-up at the edges and corners.

In the printing trade also chrome facing has been highly successful in the rotary photogravure process, and the treatment is now essential if the work is to be run at a profit. Where the average life of a copper roller has been 15,000 copies it has been found that chrome facing will produce as many as 120,000 copies, with the result that a considerable saving is effected in the time and cost of setting up the machines. These cylinders are plated horizontally and rotated in the vat. The thickness of the chrome deposit is about 0.0001 to 0.0002 in.

Hard chrome deposition has also been applied to gramophone record stampers, and in general proves valuable in most cases where abrasive conditions are experienced and the articles are not subject to sudden or violent shock.

AUTOMATIC SCREW MACHINE PRACTICE

Paper presented to the Institution, London Graduate Section, by A. W. Millward.

TO introduce this paper I will explain what is meant by the description Automatic Screw Machine ; it is a term used to cover that division of machine tools which includes all single-spindle automatic machines producing work from bar or tube, on which a complete cycle of operations is performed automatically and continually without attention from operators except of course for replenishing bars or checking components.

These machines originated in the United States, and were used almost entirely for the production of screws and bolts, but, since their introduction rapid improvements have been made, especially during the last ten years, thus making it possible to produce any article from bar or tube which it is possible to turn—that is within the machine capacity. The quantity, of course, must be taken into consideration in order to justify an economical proposition.

Not only is the machine of the present day more adaptable, but it has a cleaner appearance, for instance the attachments are driven by small electric motors, or a totally enclosed drive, instead of the early machines which were very noticeable for the number of overhead pulleys and belts.

A certain German firm markets a three-operation machine which is totally enclosed in the form of a cabinet. The appearance of this machine, especially with its total enclosure, is becoming very popular, both from the safety and cleanliness point of view.

Owing to the introduction of the new factory regulations, machine tool manufactures have had many difficult problems ; guarding a machine on the whole is a difficult proposition for one must consider the operator. For his sake the machine and guarding must be foolproof, and yet at the same time it must be so designed that it does not delay him in setting up or making it impossible to view the tools while under cut. Modern automatic screw machines are built with a very wide range of spindle speeds and feeds, in order to deal with stainless steels and alloy steels requiring low turning speeds and very low threading speeds, to free cutting mild steels and non-ferrous metals requiring the highest possible spindle speeds.

January 20, 1939.

The various types of automatic screw machines offer great scope to the machine tool designer both in the design of the machine itself, and also the various attachments which can be used to extend the scope of the machine.

Description of Machine.

Let us first review briefly the development and the various types of modern automatic screw machines. One of the early automatic machines used for producing work from the bar was the Hartford. This machine followed the general lines of the capstan lathe, the spindle being fitted with a clutch interposed between two pulleys for giving forward and reverse drive from the overhead countershaft.

A camshaft mounted in the centre of the machine carried cam drums for operating the cross slides and a six-hole turret. The bar feeding and change speed mechanism was operated in a similar way. Provision was made to accelerate this camshaft for returning the turret, bar feeding, indexing, etc. ; these are generally referred to as the idle movements. The modern development of this type of machine can be seen in the Herbert Bar Automatic and the Butterworth Automatic Screw Machine.

The characteristic features of these machines, is that the same cams may be used for various work pieces. They have a large range of spindle speeds with automatic speed changes and reverses, variable threading ratio, and accelerated movement to the camshaft for all idle movements, and bar feeding. One manufacturer of these machines claims that it is more economical to set up and operate one of these machines on gross lots than to handle the job on a capstan or turret lathe.

The Petermann Automatic which is entirely different in design from the foregoing originated in Switzerland for clock and watch parts. The particular feature of this machine is that the entire headstock can be traversed along the bed of the machine by means of a cam drum. The advantage of this headstock is that, as the work is fed forward it passes through a pilot bush, so that very small diameter and long pieces can be turned. In some cases the pilot bush is fixed, in other cases revolving, or made to suit the type of work.

The cutting tools can be arranged in two, three, or four cross slides, which are controlled by independent edge cams, so that as the bar is fed forward by the traversing headstock the tools can be independently advanced and allowed to dwell for turning, recessing, etc Provision can be made for taper turning and forming. For end working tools such as drills, reamers, taps, etc., groups of two or three spindles mounted in a swinging bracket which is controlled by a cam can be independently brought into alignment with the work spindle and fed forward the required amount.

Threading is carried out by the differential method, that is, assuming a right-hand thread is required, the work spindle is revolved at the required speed for cutting in a left-hand direction; the threading spindle is then revolved at a higher speed in the same direction; thus the amount of this greater speed is the required speed for threading. By this means the tap or die overtakes the work-spindle, and therefore cuts the thread. For withdrawal of the tap or die the threading spindle is automatically stopped.

For left-hand threads the speed of the tap or die is less than the work spindle, and for withdrawal the tap or die is not stopped, but revolved at a greater speed. These machines have become very popular for work of a long slender character.

We now come to the most familiar type of automatic screw machine, the one which is universal in its application to a large variety of work. Machines of this type are made by Brown & Sharpe, Index and B.S.A. tools. These machines are of the turret type having six tools stations and a horizontal axis. Front and rear cross slides are also fitted together with a reversing spindle for threading operations.

A distinguishing feature of these machines is the method of obtaining rapid movements. A constant speed backshaft is arranged with clutches which are engaged by trip dog on the front camshaft to give rapid feeding, withdrawal and indexing of the turret, changes of speed and direction of spindle

Two clutches are provided on the work spindle for obtaining forward and reverse speeds, and it is interesting to note that in spite of much experiment the cone type of clutch has proved to be the best for this type of work. Various types of materials can be used for the cone clutch, but that preferred in the B.S.A. automatic is a Celeron cup and steel cone.

The cams used to operate the slides are of the disc or edge type, and special cams are made for each job. The lead of these cams is highly important if best results are to be obtained, but if the instructions given by the various manufacturers is followed no difficulties should be experienced.

One piece of work is usually made for one revolution of the camshaft, and this can be varied within a wide range giving cycle times on the small machines of from one second up to two minutes.

And now to describe briefly the Index and the B.S.A. machines.

The Index turret machines are generally as previously described, the spindle being chain-driven from a gearbox in the base of the machine. High speed is in a left-hand direction and low speed in a right-hand direction, the ratio between high and low speed may be varied by pick-off gears to give high or low threading speeds, also the whole range of cutting speeds is provided by pick-

off gears. With these machines it will be noticed that left-hand cutting tools are used on all work.

Provision is made for a large number of attachments such as third slides, high speed drilling attachments, slotting attachments, index drilling attachments, etc.

There is another type of index machine in which the spindle is driven constantly in a left-hand direction and at one speed throughout the whole of the time taken to produce one piece. Threading on this machine is done in a similar way to the Petermann, that is by means of the revolving tap or die.

In place of the cross-slides swinging arms are arranged to carry the tools which not only cut diametrically but can be arranged to travel longitudinally. The advantages claimed for this arrangement are that with careful camming much greater overlapping can be done. Turning operations can be performed simultaneously with threading. Fewer special form tools are used.

The work spindle of the B.S.A. automatic screw machine is chain driven, and in the case of the smaller machine a gearbox is provided so that right-hand or left-hand high speeds and variation of threading ratio can be obtained by pick-off gears. With these machines it is only necessary to use left-hand tools when tapping.

Particular attention has been paid to the question of swarf removal ; this is very important in connection with automatic screw machines. Provision is made so that a machine can be cleaned out from the end and not from the back or front as is usual. Ample capacity is provided for swarf and coolant, and if required a mechanical conveyor can be fitted.

Another automatic screw machine which has attained a prominent place, is one generally described as the three-operation machine, and whilst the various manufacturers are not confined entirely to the production of this model I will quote the Brown & Ward as an example.

This type of machine has been greatly improved and it is an ideal machine for producing components which do not require a lot of operations. The machine is capable of very high production, its chief use being in the production of parts which require only one turret tool for drilling or screwing and two cross-slides, one for forming and the other for cutting off. These machines are easily set-up and are very economical as regards equipment.

Before leaving this resume of automatic screw machines, I would point out that this title is generally accepted as one which means a single spindle machine, and for the purpose of this paper that is the machine with which we are dealing.

I cannot, however, pass over the claim of the multi-spindle bar automatic machine to be included in this paper.

By the introduction of anti-friction bearings, improvements in material, workmanship, and design, the multi-spindle machine has become a serious competitor to the single spindle for the production of small components. The idle motions have speeded up to a degree that is truly astonishing, components being produced in a floor to floor time of two seconds, including turning, threading, forming, drilling, and cutting off. By using the method known as the two per cycle this can be reduced to one second per piece. In view of this production plus the fact that by using absolutely standard equipment a component equal in diameter but considerably greater in length to its equivalent size in the single spindle range can be dealt with, the ardent supporters of the single spindle may consider their productions from this angle.

Use of Attachments.

Automatic screw machines are capable, as previously mentioned in this paper, of producing turned parts similar to those which can be produced either on a lathe or capstan, but, in addition, there are many other operations which the automatic machine can carry out by means of special attachments. The following are in most general use: Screw slotting attachments; burring attachments; high speed drilling attachments; cross drilling attachments; milling attachments; thread chasing attachments; nut tapping attachments.

By intelligent use of the above attachments, savings can be effected in the production of components which proves that investment in these attachments is a paying proposition. The production engineer who fully realises the possibilities of the application of attachments cannot fail to increase his production and lower costs. Unfortunately in many instances the tool layouts are not sufficiently scrutinised, and are generally left to the tool setter to sort out his existing tooling equipment.

Due to the high spindle speeds and the rapid cycle times of modern machines equipped with various attachments the production times as compared with the old type automatics can generally be reduced about 25%. Each component must, of course, be treated on its merits.

The attachment which one meets most frequently is the screw slotting attachment. This is arranged generally for milling the screw driver slot in various screws, the screw being picked up at the time of cutting off and transferred to a milling cutter which mills the slot in the head. During this operation the machine is preparing another screw and so on. There are several variations, such as placing two milling cutters with a spacer between them to produce various milled forms.

A burring attachment is probably second in use to the screw slotting attachment. This is very similar in operation, the picking up and transferring being almost identical, the difference being that the pick-up bush is replaced by a spring collet or chuck that grips the component during the burring operations. This attachment, while used principally for burring or back countersinking of drilled holes, can also be used for drilling a hole in the rear end of a component.

High-speed drilling attachments used from the turret are in universal use and are essential when using small diameter drills. The drilling spindle is revolved in the opposite direction to the work spindle through the main turret and by means of bevel gears to the drill. This attachment can also be used in conjunction with revolving taps.

The cross drilling attachment is fixed to one of the cross slides. The main machine spindle is arrested by means of a spindle brake, after the driving clutch has been automatically disengaged. The cross slides on which is mounted the revolving drill is advanced and the hole is drilled at right-angles to the centre-line of the component.

Milling operations from the turret and from the cross slides are variations of the foregoing, generally being performed in conjunction with a spindle brake.

The thread chasing attachment is becoming increasingly popular as its utility is recognised. Its chief application is to cut a thread behind a flange or shoulder while the front portion is cut from the turret by the usual die method. The cutting of large diameter threads can be performed without overloading the machine. It is an easy matter to change from single start to multiple start threads, and settings and adjustments are usually quite simple.

The action of threading chasing is as follows: A single point tool, or chaser, controlled by a leader and nut, traverses the work; the leader revolves at a speed relative to the work spindle speed. Therefore it can be easily understood that if the leader, which we will assume is $\frac{1}{8}$ pitch revolves at half the work spindle speed and in the same direction, the resultant thread pitch would be $^1/_{16}$.

The operation is not completed by one traverse but by a number depending on the depth of thread, as follows: The tool travels along the work to the required length, and then withdraws sufficiently to clear the work, quickly returns to the starting point, advances, and so on until the correct depth is cut.

The nut tapping attachment is operated by means of the well-known bent tap method of continuously tapping nut type components. The nut blank is machined in the ordinary way and is then picked up by a transfer arm which in turn passes an aligning disc or fixture which places the nut in position to be passed into a hexagon

bush ; it is then passed through a process of back countersinking and so on to the tap over which it passes.

A German manufacturer namely Steinhauser market a single spindle automatic specially equipped for nut making. The main feature is the double nut gripping lever, with the aid of this lever the nut blank cut-off from the bar is taken to the countersinking tool and then to the tapping tool. The countersinking and tapping tools are set at 180° to each other, therefore when one of the arms of the gripping lever carries a nut blank to the tapping tool the second arm of the gripping lever carries a nut blank to the countersinking tool. When the double gripping lever is indexed in the correct position, the lever moves towards the tools.

A nut blank is therefore countersunk simultaneously with the other blank being tapped. A noticable feature is that the lever always revolves in the one direction thus allowing the machine to run smoothly with maximum output ensured.

Another useful attachment is bar loading. It must be realised that feeding a fresh bar through the feed finger can cause damage to a machine if the operator loads by using the feeding bracket as a ram. This bar loading attachment is in the form of two rollers which when applied by a hand lever, grip the bar which then passes through the finger without causing any strain on the machine mechanism.

To describe all the attachments and their applications would take more time than I have at my disposal, but before leaving the subject I wish to emphasise the very important part which the full knowledge of the use of attachments plays in economic production from automatic screw machines.

We now come to the economic operation of automatic screw machines.

The designers have given us very highly developed and accurate machines, which, while they are fully automatic and can be attended by semi-skilled labour, should be under the charge of first class mechanics who can appreciate the possibilities.

The first point to stress is that in every organisation using these machines, there should be at least one man who is a specialist, one who will use them to their full capacity. He should be attached to the planning or ratefixing department (or its equivalent), and all tool layouts estimating for production, and demonstrating should be his responsibility.

Second in importance are the setters employed to operate the machines ; experienced tool setters employed are often difficult to obtain and no opportunity should be missed to recruit from the general engineering shops men who have proved themselves first class mechanics. These men if given sufficient inducement, will quickly become expert setters.

One finds that a large proportion of setters have been promoted

from feed boys (or minders)—occasionally this type proves successful, but it is my experience that the toolroom fitter, or machine tool fitter is the best type to recruit.

On the average work the maximum number of machines operated by one setter should be five, and the allocation of shop orders should be arranged so that the more difficult components are evenly distributed. Attached to each battery of five machines should be a youth to feed bars into the machines and assist in the gauging of components.

All work should be paid for by the piece-work method, but special hourly rates paid for setting up or changing over. To obtain reasonable efficiency from an automatic screw machine shop is the responsibility of the shop foreman, who must arrange for his material and equipment to be ready—particularly replacement of cutting tools. He must have his labour organised to avoid productive hours being interrupted by cleaners—all swarfing and removing of components can be arranged for during the normal rest hour for meals, in special cases regular visits to clean out machines must be arranged for. Many machines have facilities for the automatic removal of swarf, or its removal without stopping production.

Cutting oils must be readily obtained, and the used oil must be filtered and cleaned for use again, and wastage of cutting oils therefore avoided.

One point which is always in the forefront is what quantities can be economically produced on automatic screw machines. I have no doubt at all that if tools are available lots of 100 can be handled more economically on an automatic than a capstan lathe. The subject of quantities is more a matter for the contracts departments, rather than the shop, and it only interests the foreman in so much that he must distribute the work to avoid overloading one setter. It should be profitable to make tools and cams for lots of 1,000; the profits side of these small lots is the responsibility of the ratefixing department, plus the organisation of the shop foreman.

It is my contention that the high speed capstan is quite as expensive, both to purchase and to run, as the automatic screw machine, and that components produced by an automatic machine are always more consistently accurate in every dimension; production times are definite because the cycle time is mechanically controlled, and not so dependent on the human element.

The type of components to be avoided on automatics are those which require very deep hole drilling and tapping in hard materials.

In closing this paper I wish to refer to another essential factor to the successful operation of automatic screw machines, and that is everything should be done to encourage interest in the machine shops, and to give the supervisors the opportunity to become acquainted with latest developments.

I wish to thank the Index Co., the Browne & Sharp Co., Messrs. Messrs. Alfred Herbert, Ltd., Messrs. Butterworth, Ltd., Messrs. B.S.A. Tools, Ltd., and Messrs. A. C. Wickman, Ltd., for information given in this paper.

Lantern Slides.

Slide No.	(1)	OR-8 index automatic screw machine—machine.
,,	(2)	B.S.A. S.S. automatic screw machine—machine.
,,	(3)	,, ,, ,, —work spindle.
,,	(4)	,, ,, ,, —apron.
,,	(5)	Wickman 10 mm. high speed precision auto.—with guards.
,,	(6)	,, ,, ,, ,, —rear view.
,,	(7)	German manufacture three-operation machine—gen'l view.
,,	(8)	,, ,, ,, ,, —view of t'ls.
,,	(9)	,, ,, ,, ,, —rear view show'g tools and cams.
,,	(10)	Brown & Ward three-operation machine—front view.
,,	(11)	Herbert 1¼ in. bar automatic – front view.

Attachments.

Slide No.	(12)	Typical layout showing cams and tools required.
,,	(13)	B.S.A. machine transferring compts to avoid damage.
,,	(14)	,, thread chasing attachment, lead screw.
,,	(15)	,, ,, ,, op. mechanism.
,,	(16)	Wickman 10 mm. auto. close-up showing tool slides.
,,	(17)	,, ,, back cover removed and slotting attachment.

FACTORY ORGANISATION IN GERMANY

Paper presented to the Institution, Birmingham, Graduate Section, by C. K. Hughes, Grad. I.P.E.

I AM going to try this evening to interest you in some of the schemes and systems of organisation which it has been my privilege to study in Germany.

Some of you already know that I was very fortunate in being sent out there early in 1936 as an Exchange Engineer. As such I was allowed to work for one year at one of the largest and best-organized factories in that country with a view to becoming familiar with their ideas and methods.

I might say here that although I was free to view the factory from any standpoint I wished, it was generally supposed that since I was a production engineer, my efforts would be confined chiefly to the technical side.

It is interesting on looking back to realise that quite early on in my stay there my attention was drawn more and more over to the organisation side. The only explanation I can offer for this is the very simple one, that this part of the business seemed to hold the greatest interest for me, and I very soon discovered that here was the most fruitful source of learning.

I was immediately struck by the great similarity which I found in the English and German methods of producing an article, and had the impression that more was to be learned by focussing my attention on to organisational methods.

Of course it was only possible for me to study one phase of the organisation, and the one in which my interests lay is best shown in slide No. 1.

Fig. 1.—Here is a list of departments, all of which find their place at some point between the initial design stage of a new product, and the actual production stage. You will see that I have bracketted these off into four sub-groups. I now propose to trace quite briefly the route of a new production through this part of the organisation, in order that you may be quite clear as to the relations of these departments to each other. Having done this, I shall return to various departments to pick out a few of the systems which I consider to be of interest.

I shall not presume to give any opinions for or against the various principles, as I prefer this to be left to the discussion later on.

Group 1.

The first group is concerned with the requirements of the customer, as passed on by the technical salesman, and is responsible for designing the product to give the results required. The departments concerned are, the designing department, the experimental workshop, and the laboratory.

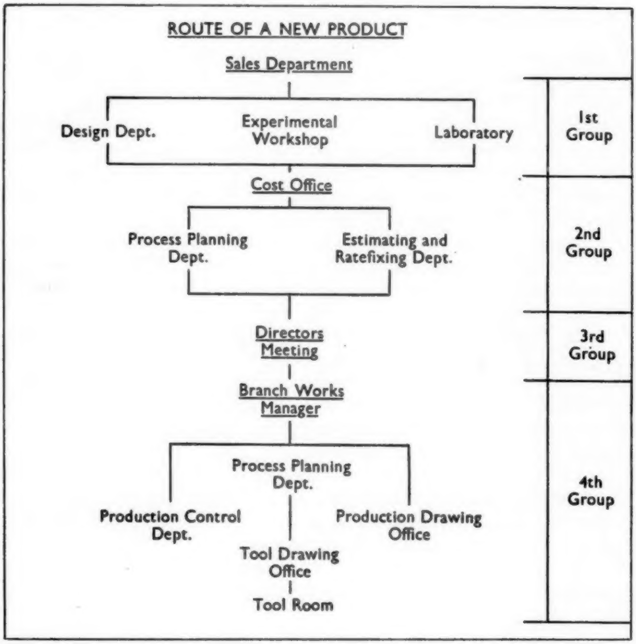


FIG. 1.

The function of the design department is to put on paper in easily readable form the fullest details possible of the new product, and then to pass this over to the experimental workshop.

Here the first model is made by hand, and many desirable developments to design usually emerge. Needless to say, designs and workshop are in closest contact with each other at this stage. The laboratory, of course, are those people who run away with the resultant model and subject it to the most rigorous and searching tests that they can devise. Of course, this is very necessary, and usually results in still further developments and improvements to design.

It will be seen that these three departments form a distinct sub-group in which a budding design may circulate perhaps a dozen times before emerging and passing on to group two.

Group 2.

This second group regards the growing design from quite another angle. Its sole interest is " How cheaply can we make this thing consistent with the limits of quality demanded ? " Obviously, this is a cost office question, and for this reason that Department must be regarded as the chief one at this stage.

It is equally obvious that this question cannot be answered by our friend the accountant, with the result that we have the rate-fixing and estimating departments and the process planning departments also incorporated in this group. As soon as sub-group one has passed on a new design, a request for a complete estimate of production cost is issued by the cost office by both estimating and process planning departments simultaneously. This request is accompanied by a complete set of design prints in each case.

The estimating department immediately commence to prepare the estimated material cost, which is fairly easily done, by pure calculation from the drawings supplied. In the meantime the process planning engineers are preparing production plans or operation sheets. These plans show every operation and tool required, and it is the responsibility of the planner to give also the estimated cost of the latter, that is, of the tools. Incidentally, this is expected to be within ± 10%.

Having completed this, the operation sheets are handed over to the estimating department, who give an estimated labour cost of every operation. The material, tool and labour costs are then compiled together on a special form and the overheads added as a percentage on labour costs, according to instructions from the higher management.

As the drawings pass through this sub-group, it is often that even further developments to design are suggested with a view to facilitating production, and so the design may revert back to the first group again.

It will be appreciated from what has already been said that a new design is well and truly criticised in this factory before any money is spent on tooling.

A design, having emerged from such a gruelling scrutiny, can well be assumed to be more or less stable, and although the Germans also suffer with the old bogey of modifications, I do think they are rather more fortunate than we are in this respect.

This I put down largely to the fact that design drawings are examined by the production or planning engineer very early in the

proceedings, in fact before production drawings have been made, and while the design is still flexible.

I would remind you that although we have proceeded so far in preparing this product for production, no decision has yet been made to produce the thing at all. This in fact is the next stage.

Of course, this example of thorough painstaking preparation is typically characteristic of the German people. It has been suggested to me more than once that too much money has been spent on this preparation and that the English method often employed of making a spot estimate is the better one, especially if in the end the product is never put into production. It must be agreed, of course, that the German practice of planning the job at such an early stage is dangerous from this point of view. On the other hand, the estimates are usually very accurate, since each item has been dealt with by the specialist.

In spot estimating, one man (the estimator) is usually expected to arrive at a production cost himself, which means he either has to be an exceptionally capable man, or, which is more often the case, he resorts to statistics, and with the aid of these makes what can only honestly be called a guess.

In these days of highly specialised mass production statistics are themselves dangerous owing to the rapid changes and developments which are constantly taking place in production methods.

Of course, in a jobbing shop where relatively small quantities are produced on standard machinery, the position is different. I must continually remind you that the scope of this paper is confined to very large mass production factories, where decentralisation is the order of the day.

Coming back to our new product, we have now arrived at group three.

Group 3.

You will see from the slide that this group is one of individuals and not of departments. It is a meeting of the technical chiefs and the directors. Here the results of the engineer's efforts are placed in the hands of the financial specialists, who make a decision as to whether the article is saleable at a remunerative price.

Assuming this to be so, the Directors authorise the issue of a sanction to spend the estimated amount in producing the article, and usually delivery dates are discussed with the technical chiefs of the factory.

Group 4.

The issue of this sanction is the signal for activity for the fourth group, which consists of the production control department, the

process planning department, the tool drawing office, and the tool room, all under the supervision of the branch factory manager.

This official calls a " freigabe sitzung " which is best translated as a " release meeting " and representatives of all these departments are present.

The sanction, which takes the form of a printed leaflet, very similar in appearance to an English patent specification, contains a sketch of the new product and a simple but lucid description. The fundamental difference from previous productions being amply explained for the benefit of everyone.

Copies of these sanctions are usually issued to those concerned some time previous to the meeting in order to give everyone a chance to study them. The immediate concern of the meeting is to establish a date on which production shall commence.

The production drawing office, having already studied the sanction, is expected to give a promise for protection prints, and the process planning department guarantee to have all tools on order by a certain date.

It will be realised that since the job has already been planned once, this ordering of tools is a fairly quick job. The fact that the drawing of production prints has been held back to this comparatively late stage has the advantage that better co-operation is possible between production draughtsman and production planner, with the result that agreement can be reached on many controversial points. This obviates those small annoying modifications to design, which would otherwise be requested by the planner, and which can be so expensive in a large factory.

In the factory with which I am associated here in England, one such modification can cost as much as £3 in clerical and stationery expenses alone. In addition, tool designs must of course be promised and, as a logical sequence, the tools themselves. The tool design and the tool room rely on the planning engineer for the information on which these promises are based.

The production control department take due note of all parts which are to be bought out with a view to ordering them, and all parts which are to be made on the ground in order that the production sequence can be planned.

The minutes of the meeting are compiled by the secretary and a report showing all promises is published the next day.

That is a brief description of the route of a new product through the particular organisation to which I refer.

I think one of the outstanding differences between this organisation and its equivalent in England is the point at which the production sanction is issued.

The amount of work required to prepare a job for production is exactly the same, whether in an English or a German factory, but

you will see that in the German factory much more of it takes place before the sanction with a minimum after it, while in England, the opposite holds good.

I hope some of you will give your impressions on this point when the meeting is thrown open for discussion.

<table>
<tr><td rowspan="13">Total time for a batch (TT).
TT = (OT × X) + ST
X = Number of parts in the batch.</td><td rowspan="2">Setting time (ST)</td><td colspan="3">Setting time (effective) (STE)</td></tr>
<tr><td colspan="3">Setting time (ineffective) (STI)</td></tr>
<tr><td rowspan="11">Operating time (OT)</td><td rowspan="4">Floor to floor time with no allowances (FFT)</td><td rowspan="2">Ineffective work'g time chucking, dechucking, and all idle tool movements (IWT)</td><td>Hand work</td></tr>
<tr><td>Machine work</td></tr>
<tr><td>Cutting time (CT)</td><td>Hand work
Machine work</td></tr>
<tr><td>Dead time (DT)</td><td></td></tr>
<tr><td colspan="2" rowspan="3">Efficiency factor for particular worker (EF)</td><td>Diligence</td></tr>
<tr><td>Dexterity</td></tr>
<tr><td>Working speed</td></tr>
<tr><td colspan="2" rowspan="2">Lost time (LT)</td><td>Positive</td></tr>
<tr><td>Abstract</td></tr>
<tr><td colspan="3">Special allowance (SA)</td></tr>
<tr><td colspan="3">Special efficiency factor when two or more machines attended (SEF)</td></tr>
</table>

FIG. 2.

Ratefixing and Estimating.

I now propose to retrace my steps somewhat to the ratefixing and estimating department, with a view to giving you a little more detail.

In the first place it is interesting to note that one department covers both functions, that of ratefixing and that of estimating.

I know that this is also the case probably in the majority of English factories, but there does seem to be a tendency for these to become separated, especially in the larger factories. It is with this separation

that the system of spot estimating and the use of statistics creeps in with the consequential inaccuracies.

I don't want to give the impression that I consider statistics themselves to be inaccurate or that the Germans do not use them, in fact, quite the reverse is the case. The Germans use their statistics far more than we do, but apply them rather more cautiously. We tend to make our statistics cover too wide a field, while the German statistics deal always with absolute fundamentals only.

It rather reminds me of the old examination question: "If a 4 in. vice costs 5s. to make, and a 6 in. vice costs 6s., what would an 8 in. vice cost?" Of course, the answer is 7s.

A German would not attempt to use his statistics in this way, but confines them to such elements as "load and unload the jig," "blow out the jig," "drill hole," etc. You will see that he is infinitely more painstaking in this respect and would prefer to estimate the cost of 8 in. vice right from fundamentals, in other words, he would want operation sheets first for each part. This rather explains the position of the process planning department in Fig. 1.

As a matter of fact, the firm with which I worked have produced the most complete book of production engineering statistics that I have ever seen. This they call the "norm book."

Norm Book.

I have mentioned this at this stage because in reviewing the ratefixing system it will be necessary to mention it at times. The Germans have a standard ratefixing system which is recognised and supported by the Government, this is called the "Refa" system, spelt R.E.F.A., these being the initial letters of a famous German firm of time study engineers.

I am not a time study engineer and cannot claim any real experience in this direction but from the little knowledge I have, I think I can say that in principle this system resembles the famous "Bedaux" system.

Fig. 2 shows the Refa method of splitting up a cycle into its various elements.

Dead Time.

This only occurs when an operator serves more than one machine and is that time during which no work is done, e.g., an automatic waiting for bar.

Lost Time.

This is the time during which production ceases and is split up into two elements, "positive lost time" and "abstract lost time." Positive lost time is that required for such operations as grinding and

resetting of tools, and greasing and cleaning the machine, all of which are to be found in the norm book. Abstract lost time is that required for signing job cards and personal requirements.

The Efficiency Factor.

The efficiency factor is equivalent to the Bedaux rating figure, except that the standard is 100 instead of 60. In this system, as in others, this percentage of personal efficiency is the main abstract factor, and as such, is always open to criticism.

In an attempt to simplify its assessment, it has been divided into three factors, diligence, dexterity, and working speed. The principle being that each factor shall be assessed separately and the resultant taken as the rating figure.

It is hardly feasible to give each a normal value of $33\frac{1}{3}\%$ in order that the sum shall be a percentage since assessment would then be very difficult. For this reason each has a normal value of 100 and each is separately assessed by the ratefixer on this basis.

Having got so far, the three factors have then to be reduced to a single percentage. This is not done by adding them and dividing by three, but by the employment of a special reducing factor for each.

Diligence...	0.2
Dexterity	0.4
Working speed	0.4
Total	1.0

Example—

Diligence (over normal)	110	× 0.2	=	22
Dexterity (under normal)	90	× 0.4	=	36
Working speed (over normal)	115	× 0.4	=	46
Efficiency factor				104%

In certain special circumstances these " reducing factors " can be different, but their sum must always equal 1.0.

FIG. 3.

Fig. 3.—These factors are given in Fig. 3, and seem to suggest that the components, dexterity and working speed are each twice as valuable to the firm as that of diligence. I make no remarks on this, but some of you might like to find a reason for it later on.

When making a study in the shops, the first procedure is to study the operation as a whole, and having decided that there are no obvious faults, to split it up into suitable elements. Each of these will be either " cutting time " or " ineffective working time," but must not, of course, be a mixture.

Timing of the elements can now commence and can be done either by timing each separate element and then returning the watch to

zero for the next, or by allowing the watch to run continuously and taking a reading at the end of each element. The latter is considered more accurate since no time is lost in returning the watch to zero This method, however, involves more work since each value must be calculated on completion of the study. The observed times are filled in on a special form until 20 complete cycles have been timed. The next procedure is to find the average value for each element and enter it into one of two columns according to whether it is actual " cutting time " or " ineffective working time." It is then possible to add all elements, and so obtain two times, one CT and the other IWT, the sum of which gives the " floor to floor time " (FFT).

Two methods of finding the average value for an element are used. The first is the normal method, by which all values are totalled and divided by the number of readings. The second method is called the " Central Value " method.

In this case, the values are rewritten strictly in order of size, the minimum on the left-hand side and the maximum on the right. The value which is accepted as the average is the central one. It is interesting to note that on the standard forms, where 20 readings are taken, there is no central value, since 20 is an even number. Value number 11, counting from the left, is the accepted one.

COMPARISON BETWEEN MATHEMATICAL AVERAGE AND " CENTRAL VALUE."

.05	.06	.06	.07	.07	.08	.09	.09	.09	.1	.1
	.1	.1	.1	.1	.1	.1	.1	.11	.11	

The eleventh value gives 1
The mathematical average gives ... ... .089

It is realised, of course, that this is a bad example since the variation of readings is too great. It serves, however, to illustrate the point.

FIG. 4.

A comparison between these two methods is very interesting, and well worthy of study. While the first gives a value which is a more true mathematical average of the times taken, the second method has the advantage that it tends to eliminate the effect of any abnormally high or low readings. Therefore, although the second value is not a mathematical average, it may be a more true value for the particular element.

Fig. 4 gives an interesting example of this method of averaging. Of course, this is a somewhat exaggerated example, owing to the large variations in the observed times, but it does show up quite effectively the varying results obtained by the two methods. Actually the Germans always apply a simple test to such a set of readings before doing any calculations, in order to be quite sure that the observed times do not vary beyond a prescribed limit.

This limit is known as the " Schwankungsfaktor " or " Variation Factor " and is the ratio of mathematical average to minimum value. Should this ratio exceed 1.25 then a new study is considered necessary. In other words, the greatest permissable difference between the average and minimum readings is in the ratio of 100 to 80—20%. This test is often applied to each element of an operation as well as to the operation as a whole.

Having arrived at a satisfactory value for " ineffective working time " and " cutting time " the question of " efficiency factor " must be considered. It is assumed that values have been allotted during the study for " diligence," " dexterity," and " working speed " and these can now be multiplied by their respective reduction factors and the " efficiency factor " found. Only the " ineffective working time " is multiplied by this factor, that is, such elements as load and unload machine, index machine, clean locations, etc.

CUTTING TIME (CT)

Drill	1	hole	14.0 mm. dia.	7.4 mm. deep	... ... 0.13	mins.
,,	2	,,	6.5 mm. ,,	5.0 mm. ,,	... ... 0.12	,,
,,	2	,,	8.5 mm. ,,	5.65 mm. ,,	... ... 0.18	,,
,,	4	,,	5.3 mm. ,,	4.5 mm. ,,	... ... 0.24	,,
					0.67	mins.

INEFFECTIVE WORKING TIME (IWT).

(1)	Load and unload jig	0.275	mins.
(2)	Blow out jig with compressed air	0.030	,,
(3)	Slide jig from one spindle to next (four times)	0.080	,,
(4)	Feed drill down to the work and back (nine times) ...	0.135	,,
(5)	Swill the finished part	0.040	,,
(6)	Gauge nine holes once in every 20 parts	0.016	,,
		0.576	mins.

FIG. 5.

All other elements which are independent of the operator, that is all cutting times which are governed by tools, material and plant are left unaltered. This factor is purely a " personal efficiency factor."

The remaining " lost time " can be found from the " Norm Book."

The " abstract lost time " being a personal allowance is standard for all operators and is rated at twenty minutes per day.

The " positive lost time " that is, time for grinding and resetting of tools is tabulated in the " Norm Book " according to type of machine and operation.

The addition in all these times, gives, of course, the " operating time " on which the wages are calculated.

That is a very brief resume of the German method of ratefixing, and while essentially the same in principle as our method, there are one or two interesting differences.

I will now give you a glance at the estimating side of the job. I think the best way to do this is to follow through an example which I worked out personally while in the Department. The whole thing is based on the " Norm Book " all values being found in tabulated form.

This will illustrate what I said just now about statistics, and will give you a typical example of how the Germans apply them. Let me commence by saying that my estimated figure after wading through all the necessary tables came out at 1.37 minutes. On checking up, the actual time was found to be 1.54 minutes, which was an error of 11%. Considering I was a complete novice in the use of the " Norm Book," I think this speaks quite well for its wonderful layout. I repeat that this book is by far the most remarkable collection of production engineering statistics that I have ever seen.

The operation to be estimated was that of jig drilling (9) holes through a plate ; and the first essential, before the " Norm Book " was consulted, was to produce a detailed plan of this operation with all its elements. This is shown on Fig. 5.

You will see that the elements have not been written down in order, as performed, but have been grouped into " cutting time " and " ineffective working time." The values for the actual cutting times are tabulated according to diameter and depth with multiplying factors for all materials.

Although the job under consideration was a plate of constant thickness, you will see the depth of holes vary in each case ; this is explained by the fact that the point of the drill must vary in length according to the drill diameter, and, of course, the actual depth drilled is the thickness of the material, plus the length of the drill point. All this was covered by appropriate tables in the " Norm Book."

The values for the other group of elements were tabulated as follows : (1) Drawings of different types of jigs given and two values given for each. One value for when the jig was fixed to the table, and vice versa. (2) According to the weight of the jig and whether air pipe was fixed or flexible. (3) According to the weight of the jig. (4) According to the make and size of drilling machine. Two values given, one for the case of easy entry of the drill in the bush, and one for when entry was in any way obstructed. (5) According to the weight of the parts. (6) Both the frequency of gauging and the time required were tabulated according to the limits on the drawing.

All these last values include the efficiency factor and, therefore, no additions have to be made to cover this.

We must, however, add a figure for "lost time" and this was given by the Book as 10%. This is tabulated according to the type of machine, number of drills to be kept in condition, etc. Since this 10% includes both "positive" and "abstract" lost time, it is added to the total floor to floor time and not just to the cutting time.

This now gives us :—

Cutting Time	0.67	Minutes
Ineffective Working Time ...	0.576	,,
TOTAL	1.246	,,
± 10% Lost Time	1.37	,,

Fig. 6 shows the estimation of "setting time" on the same job.

Since I still have a lot of ground to cover, I do not propose to spend any more time on the Ratefixing and Estimating Departments, but would like now to say a few words about the Process Planning Department.

SETTING TIME FOR THE SAME JOB.

(1)	Fetch blue print and read	3.0	mins.
(2)	Fetch four drills, four plug gauges, and one jig from stores and take back	7.0	,,
(3)	Grind four drills, chuck, and dechuck four drills, drill and gauge first part	15.0	,,
(4)	Arrange work near the machine for the operator and place jig	3.5	,,
(5)	Set stops on four spindles	8.0	,,
(6)	Loosen stops on four spindles	4.0	,,
(7)	Remove all swarf and clean down the machine table ...	2.0	,,
	Total	42.5	mins.

FIG. 6.

As far as the technical side of the factory is concerned it may be said that this department enjoys a very high status indeed, in fact, it is virtually the heart of the Production Engineering group.

Its functions are wide, and include, as well as the establishment of production methods, the control of tool designs, the estimation of tool costs, the buying of plant, and the laying out of the shops to suit line production. This department is generously staffed in order that the typically German principle of thorough preparation may be upheld. This certainly seems to have excellent results, since the number of engineers necessary in the shops to get the various "setups" running is practically nil.

It should be borne in mind that the whole planning system is quite old and very well established in Germany. The process planning department is already twenty years old, which no doubt has a big bearing on its efficiency. The personnel of this department were very carefully chosen, the men were first and foremost essentially practical, but a sound theoretical training was also insisted upon. The Germans seem to have the happy knack of obtaining that rather delicate balance between theory and practice which is often so difficult to find and yet so essential to efficiency.

One very interesting principle I came across in this department was its attitude to urgent and non-urgent orders. Every endeavour was made to clear all work as it arrived whether urgent or not, the only difference in the orders being the required delivery date.

The result of this policy is that the tool design and toolroom are supplied with a constant stream of orders, some of which are urgent and others non-urgent. This is an ideal condition since it allows the chiefs of these departments to space the work accordingly.

The toolroom foreman for instance always has tools in the shop with a long delivery date which he can use as a balancing load to keep his machines busy. The turning for one of such tools may be done in one week and it can then be laid aside until a milling or shaping machine becomes available.

It has been my experience that non-urgent orders are often held up in the planning stage until they eventually become urgent ones, with the result that tool designers and tool makers are harassed by a continuous supply of urgent work.

Of course, the principle of giving urgent work preference and of holding back non-urgent work s sound, but the quèstion which presents itself is : " Where can this permitted delay be used to the greatest advantage ? "

There are three main departments concerned, the process planning, the tool design, and the toolroom. In the first two departments, a job, if once started upon, must be finished right through if the best results are to be obtained, but in the toolroom a non-urgent job can be allowed to filter through the department, each stage of its manufacture being completed as the opportunity arises.

Furthermore in the first two departments the total load on the office can always be evenly distributed ; if one section is busier than another the busier section can always obtain help from the other. In the tool room this is not possible, for example an idle planning machine cannot be used to help out the turning section. For this reason a balancing load of non-urgent planing work would prove very helpful. This is one of the reasons then for the somewhat generous staff of the process planning department in this organisation.

Before passing on to the next department I must not omit to give you a short description of the method of load control which is employed here, as this struck me as being of particular interest. The process planning department, bieng the king pin of the technical part of the organisation, endeavours, with considerable success, to keep a constant inventory of the load on those departments which it feeds. These are: The tool drawing office, the tool ratefixing department, and the toolroom.

To attempt to describe this system in detail would necessitate a lecture on its own, but in order to put the main principle before you, I will describe the method employed of loading the tool drawing office.

The first essential to the working of a system of this kind is that all outgoing work from the process planning department must pass through a central point for recording purposes. Similarly all work completed by the tool design department must also be reported each day to this central control point. In this way, the actual change of load on the department can be calculated each day by adding the ingoing work and substracting the outgoing work. Of course this change of load can be either positive or negative according to circumstances.

The real interest in this scheme lies in the method employed of deciding just how much work is placed on the department by each order issued to it.

The order bears in each case a description of the tool but this does not provide any concrete basis on which to assess the drawing hours involved, in addition, however, the order always bears the planners estimated cost of the tool and this is the figure which is used as a loading basis.

In the particular case under consideration it is known from the daily reports that an average day's output from the tool drawing office is equivalent to RM.1,600, worth of making.

Having this figure as a basis, and having also a constant inventory of the load in marks on the department it is an easy matter to give at any time the load in days or weeks. By pushing a little further, still more interesting information can be gleaned from the figures shown by this system.

For instance, if the average daily output for the tool drawing office is known to be RM.1,600, it is an easy matter to calculate the hourly output per draughtsman.

This hourly output per man is in terms of money but by dividing by the toolroom hourly rate this is easily converted to man hours of tool making. In this way a direct ratio can be found of draughting hours to toolmaking hours.

This ratio naturally indicates the ratio of toolmakers to tool draughtsmen, which is required in order to keep the two depart-

ments in balance. I have calculated this figure both in the German factory and in an English factory and in both cases I arrived at the same figure.

With your permission, I would prefer not to give this figure at the moment but to leave this for consideration during the discussion. It has alredy been the subject of much discussion between myself and other engineers here in England.

Let me point out at this stage that this ratio of draughtsmen to toolmakers is related only to that proportion of the toolroom which is engaged on the production of brand new tools. All other toolmakers engaged on maintenance work and the manufacturing of additional tools for which designs already exist will be additional to this figure. To put it in a nutshell, how many toolmakers can be kept fully occupied by one tool draughtsman assuming that no maintenance work is involved?

Having got so far with this paper, it is now apparent that I cannot hope to cover all the ground I intended to. I wanted to talk about a bonus scheme which is employed in the tool drawing office and also the methods used to plan the production sequence in the production control department, but it seems that I must be content with covering only one more item, that being the inspection department. I have picked this out because of a particularly interesting system they have of keeping a check on the condition of all gauges in the factory.

This system has been inaugurated with a view to ensuring that all gauges and instruments are returned at definite intervals to the checking section. One of the first problems in starting up such a system is to fix the interval or " gauging period " after which each gauge must be called in.

This in turn is dependent upon the amount of wear which may be tolerated on the gauge before it is scrap. This permitted amount of wear is fixed at one-tenth of the tolerance covered by the gauge. That is to say that a go and not go plug of $\frac{1}{2}$ in. $\pm$ .005 would be allowed to wear .0005 in. after which it would be scrapped for that particular job.

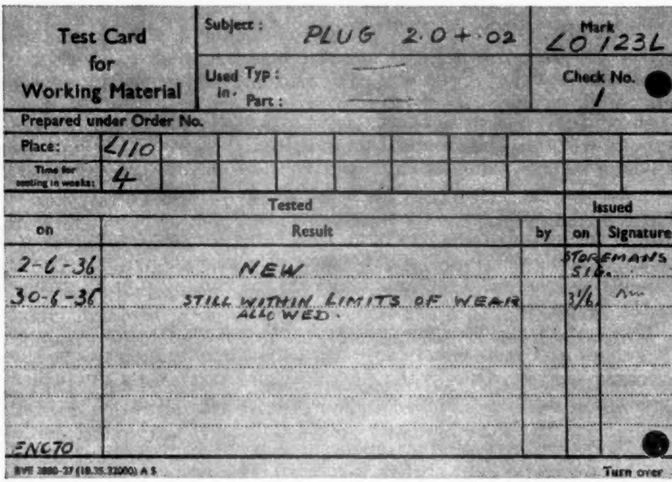
The object when fixing the gauging period is to arrange that each gauge is checked about four to six times during its useful life, more would be too expensive and less would be dangerous. The results of each check are of course recorded on an appropriate card which then shows a clear picture of the " rate of wear " of the gauge. (See Fig. 7).

The fixing of the "gauging period" is difficult to do in a scientific way owing to the number of variables involved. For this reason the following rule is worked to :—

When the permissible wear is (.0004 in.) .01 mm. the gauging period is fixed at two weeks.

When the permissible wear is (.0008 in.) .02 mm. then the gauging period is fixed at four weeks.

All gauging periods must be an even number of weeks in order that a complete turnover takes place in each year. These periods must be either two, four, six, eight, twelve, sixteen, twenty-four, or forty-eight weeks. When fixing the "period" for a new gauge this is kept on the short side rather than too long for the sake of safety. You will see later that this sytem allows for the alteration of this "period" as circumstances permit.


Test Card for Working Material
Subject: PLUG 2·0 + ·02
Mark LO 123L
Used in · Typ: ——
Part: ——
Check No. 1
Prepared under Order No.
Place: L110
Time for testing in weeks: 4

Tested on	Result	by	Issued on	Signature
2-6-36	NEW		STOREMANS SIG.	
30-6-36	STILL WITHIN LIMITS OF WEAR ALLOWED.		3/6.	
ENC70				

Turn over

FIG. 7.

A special system of filing has been developed to assist in the running of this system. Every gauge and instrument in the factory has a card made out in duplicate, and these cards are filed together in one of 48 drawers. Each one of these drawers represents a working week, and there are 48 of these so a complete year is just covered.

When a new gauge is issued by this section to the shops, its two cards are filled in showing the date of issue, and to which stores it has been issued, and also the gauging period. Should the date of issue be in the twentieth week, for example, and should the gauging period be four weeks, then the two cards are filed away in drawer No. 24.

On the twenty-fourth week drawer No. 24 is emptied of all its cards, and while one of the duplicates remains behind as a check, the second card is sent to the stores and must be returned immediately with its gauge.

The gauge is checked, the data filled in on the card, and the latter is then refiled in the twenty-eighth drawer if its gauging period is four weeks or in the thirtieth drawer if the period is six weeks, and so on.

If a gauge, after being checked several times, seems to show no appreciable wear, then the checker is at liberty to cross out the existing gauging period on the card and lengthen it. Similarly, he can shorten it if he thinks this advisable. In any case he gets a very clear picture of the *rate of wear* of a gauge and is thus enabled to order a replacement in advance. Should he do this, the order must pass through the process planning department in order to make sure that the part for which it is intended is not absolete.

Before passing on, I will give you a few typical gauging periods. Screw gauges up to 10 mm. (male or female), four weeks; screw gauges over 10 mm., eight weeks; voltmetres, ammetres, twelve weeks.

It is worthy of note that five inspectors on this section check on average 4,000 gauges per week. This is less than 4 mins. per gauge. Two of these inspectors are girls who concentrate on plug and gap gauges, and, needless to say, all are on a bonus system.

Before I close, I suppose I ought to mention A.R.P. in order to keep quite up-to-date. The position is summed up very well when I say that in 1936 the Germans were somewhat more advanced in A.R.P. than we are to-day. During my stay there I witnessed several black-outs, some only in the factory, and some embracing the whole town.

Every window in the factory was fitted with permanent black blinds and alarms were being tried out almost every day. Quite a new industry had already sprung up for the manufacture of motor car head-lamp shields which only permitted a thin slit of light to leave the lamps. This is said to be invisible from above.

Telephonic systems of spreading an alarm were all prepared in plan form, the central alarm office would ring about six numbers, each of these would then ring six numbers, and so the alarm would be spread throughout the organisation with the utmost rapidity.

Every department had a plan at hand showing exactly which numbers were to be given the alarm. This would avoid the duplication of alarms and the jamming of the automatic telephone exchange.

In concluding this paper I would like to express my gratitude to my firm for giving me such a wonderful experience in Germany, and also for their permission to read this paper.

ANNUAL REPORT

and

ACCOUNTS

For the Year ended June 30, 1939

(with First Report and Accounts of the Research Department)

To be presented at the

ANNUAL GENERAL MEETING

October 20, 1939

At Institution Headquarters,
36 Portman Square,
London, W.1.
at 2-30 p.m.

THE INSTITUTION OF PRODUCTION ENGINEERS

Balance Sheet as at 30th June, 1939

Liabilities.	£	s.	d.	£	s.	d.
Sundry Creditors:						
Head Office	354	7	8			
Research Department .	24	11	6			
				378	19	2
Amount due from Head Office to Research Department per contra .				495	0	1
Subscriptions Received in Advance				30	10	1
The Viscount Nuffield Gift ...				24000	0	0
(*Balance, after transferring* £1000 *to the Research Department*).						
The Lord Austin Prize Fund	52	10	0			
Hutchinson Memorial Fund	37	12	6			
				90	2	6
Leasehold Premises Sinking Fund .				127	3	4
Income and Expenditure Account:						
Balance at 1st July, 1938	5464	0	10			
Add Excess of Income over Expenditure for the year	456	3	2			
				5920	4	0
Research Department:						
Balance of Income and Expenditure Account				548	7	1

Assets.				£	s.	d.	£	s.	d.
Leasehold Premises at cost ...							3481	0	0
(Depreciation is provided by a Sinking Fund).									
Furniture, Fittings, and Plant at cost *less* amount written off:									
Balance at 1st July, '38				727	11	0			
Additions during the year				67	11	3			
				795	2	3			
Less amount written off				139	10	11			
							655	11	4
Research Department: Laboratory Plant and Furniture at cost ...							75	5	2
Investments at cost:									
5% Conver. Stk. 1944-64	£7269	13	8	8000	0	0			
3% National Def. Stock 1954-58 ...	8389	9	6	8000	0	0			
3¼% Canada Reg. Stock 1958-63 ...	8175	2	6	8000	0	0			
Plym'th Cor. 3% Stock 1956 ...	588	3	0	591	18	6			
Ayr County Council 3% Stock 1956.	625	17	1	630	9	6			
London Cty.	600	0	0						

	600 0 0	London Cty. Con. 3% Stk. 1956-61 ...	603 17 0	
	25648 5 9		£25826 5 0	
		Less profit on re-investm't	206 1 1	
				25620 3 11
		(Market value £25441 3s. 4d.)		
		LEASEHOLD PREMISES SINKING FUND POLICY		127 3 4
		SUNDRY DEBTORS		308 9 8
		SUBSCRIPTIONS IN ARREAR, *not valued*		—
		RESEARCH DEPARTMENT:		
		Due from Head Office per contra	495 0 1	
		Cash in Hand... ...	2 13 4	
				497 13 5
		CASH:		
		At Bank	789 2 11	
		In Hand	35 16 6	
				824 19 5
£31590 6 3				£31590 6 3

(*Signed*) JAMES G. YOUNG, *Chairman of Council and Finance Committee.*

(*Signed*) J. H. BINGHAM, *Chairman, Research Committee.*

(*Signed*) R. HAZLETON, *General Secretary and Treasurer.*

AUDITORS' REPORT.—We have audited the above Balance sheet dated 30th June, 1939, and we have obtained all the information and explanations we have required. In our opinion such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Institution's affairs according to the best of our information and the explanations given us, and as shown by the books of the Institution.

Aldwych House,
London, W.C.2.
1st September, 1939.

(*Signed*) GIBSON, APPLEBY & Co.,
Auditors,
Chartered Accountants.

THE INSTITUTION OF PRODUCTION ENGINEERS

Income and Expenditure Account for the Year Ended 30th June, 1939.

Dr.

		£	s.	d.
To Salaries		1247	11	7
,, Rent, Rates, Lighting, Heating, and Cleaning		550	13	0
,, Local Section Expenses		443	18	7
,, Printing, Postages, Stationery, Telephone, and Certificates		478	4	0
,, Cost of, and distribution of, Journal		1097	10	3
,, Travelling and Expenses of General Meetings		308	1	2
,, Professional Charges and Insurances		46	6	11
,, Donations to other organizations .		15	5	0
,, Library		23	11	1
,, Repairs and Renewals		38	11	0
,, Examinations, *less* receipts ...		28	1	4

Cr.

		£	s.	d.
By Subscriptions received :				
Current	3752 18 6			
Arrears	136 8 0			
		3889	6	6
,, Interest on Investments		206	17	1
,, Receipts from Sales and Advertisements of Journal		1021	4	0
,, Contributions to Research		31	5	0
,, Contributions to Leasehold Premises		8	8	0
,, Transfer from Donations Account...		1000	0	0
,, Transfer from Research Account for Preliminary and Management Expenses		200	0	0

	£	s.	d.		£	s.	d.
,, Annual Dinner, *less* receipts ...	27	9	4				
,, Miscellaneous	50	1	0				
,, Transfer to Leasehold Premises Sinking Fund	127	3	4				
,, Amount written off Furniture, Fittings, and Plant	139	10	11				
,, Amount transferred to the Research Department Account	1278	18	11				
	5900	17	5				
,, Balance, being Excess of Income over Expenditure	456	3	2				
	£6357	0	7		£6357	0	7

DONATIONS ACCOUNT

	£	s.	d.		£	s.	d.
To Transfer to Balance Sheet (The Viscount Nuffield Gift)	24000	0	0	By Donation from The Viscount Nuffield	25000	0	0
,, Transfer to Income and Expenditure Account	1000	0	0				
	£25000	0	0		£25000	0	0

THE INSTITUTION OF PRODUCTION ENGINEERS

RESEARCH DEPARTMENT

Income and Expenditure Account for the First Half Year Ended 30th June, 1939

	£	s.	d.		£	s.	d.
To Salaries and Wages	409	5	0	By Grants from the Institution, including £1,000 from The Viscount Nuffield Gift	1247	13	11
,, Preliminary and Management Exs.	200	0	0	,, Transfer from the Institution of Contributions received for Research .	31	5	0
,, Printing and Stationery	4	12	6				
,, Removal Expenses	50	0	0				
,, Travelling Expenses...	34	17	1				
,, Professional Charges	19	19	0				
,, Technical Publications	6	11	1				
,, Laboratory Materials	4	17	2				
,, Miscellaenous		10	0				
	£730	11	10				
,, Balance transferred to the Institution's Balance Sheet	548	7	1				
	£1278	18	11		£1278	18	11

ANNUAL REPORT FOR THE YEAR ENDED 30 JUNE, 1939

To be presented by the Council to the Annual General Meeting, London, 20 *October,* 1939

The War.

THE Annual Report of the Council usually covers the twelve months to the end of June each year. The outbreak of war, however, makes it necessary to depart from that practice on this occasion.

The Central Register.

Very large numbers of members of the Institution have for a considerable time past been engaged in the manufacture of armaments and other essential war supplies. When the Central Register was set up by the Ministry of Labour, one section of this (735) was allocated to Production Engineering, divided into the following manufacturing classifications: (1) General; (3) aircraft; (5) armaments; (7) automobiles and accessories; (9) electrical equipment; (11) scientific instruments; (13) locomotives, parts and accessories; (15) machine tools and plant; (17) jigs, fixtures, tools, press tools, gauges; (19) naval and shipbuilding equipment; (21) others.

Our Institution is represented on the General Engineering Committee of the Ministry of National Service and Labour by Mr. J. D. Scaife, and on the Mechanical Engineering Committee by Mr. G. H. Hales. The following members have been appointed by the Council to act for the Institution on Regional Panels of the Mechanical Engineering Committee of the Ministry: East Midland—Mr. L. Austin, Leicester. Midland—Mr. R. C. Fenton, Birmingham. North Eastern—Mr. J. Nicod, Hebburn-on-Tyne. North Western—Mr. W. Core, Stockport. Scottish—Mr. I. Garvie, Glasgow. South Wales—Mr. G. Thompson, Swansea. Southern—Mr. H. W. Denny, Portsmouth, and Mr. L. Page, Reading. Western—Capt. A. C. Burgoine, Bristol. Yorkshire—Mr. A. Sykes, Huddersfield.

The Unofficial Register.

The official Register has so far been restricted to Ordinary Members and Associate Members of the Institution, but it has been decided that the Institution should open and operate an unofficial Register for all other membership grades, except students. This will serve a very valuable purpose, and will ensure that particulars

of members of all grades other than that of student can at any time be transferred to the official Register, subject to the consent of the members concerned.

Utilising Local Knowledge.

The development and operation of the Registers, official and unofficial, are likely to form a major activity of the Institution during the war. It may well be that our 16 senior Local Section Committees will be required later to play an active part in the working of the Registers. Steps have been taken to enable them to function in this respect if need be. Apart from possible interruption of communications which might make it difficult to operate a Central Register successfully, it would seem desirable to utilise the knowledge which Local Section Committees can supply.

Headquarters to Remain in London.

It has been decided not to move the Headquarters of the Institution out of London during the war. Should circumstances arise to force a change in this policy, a move would probably be made to Loughborough, where the Institution's Research Department was established in January, and where it is continuing to function.

Records, Etc. Moved to Cornwall.

Meantime, irreplaceable documents, pictures, records, etc., belonging to the Institution were moved to Cornwall prior to the outbreak of war for safe keeping, where our Chairman of Council, Mr. James G. Young, has kindly arranged to house them in the special strong room built by his firm to guard against war risks.

Meetings During the War.

The Council have advised Local Section Committees that no hasty decision should be taken to cancel all fixtures. If circumstances allow, it might prove practicable to hold lecture meetings on Saturday afternoons, or other convenient times.

Membership.

The membership at the end of June, 1939, was as follows :—

Honorary Members	3
Ordinary Members	701
Associates	35
Associate Members	746
Intermediate Associate Members ...	77
Graduates	403
Students	6
Affiliates representing 44 Affiliated Firms, less 10 already in other grades	37
	2,008

Three hundred and sixty-four new members were added to the Register during the year. Four members died, 23 resigned and 16 lapsed. The members whose decease has to be recorded with much regret were : Sir Walter Kent, C.B.E., President, 1933-35, Mr. L. Maxwell-Stewart, Mr. A. Harrison, and Mr. A. S. Ronald. The death of Sir Walter Kent was a great loss to the Institution, in the affairs of which he took a most active interest up to his last illness.

It will be noted that membership is now over 2,000. At the meeting of the Council on June 10, 1939, it was decided that the candidate who, by completing his election, brought the total membership to 2,000 should have the fact recorded on his certificate. He was Mr. C. N. McLaren, Director General of Ordnance Factories, who completed his election on June 22.

In the membership totals this year two new grades appear for the first time—Intermediate Associate Member and Student. Some of the older engineering institutions include over 2,000 students in their membership. The development of our educational policy made it necessary to create this grade, and it is hoped that senior members will take an active interest in the enrolment of students. The Intermediate Associate Membership grade has long been contemplated, and it also is designed to serve a valuable purpose in connection with the educational plans of the Institution.

Finance.

The outstanding feature of the year was the gift of £25,000 from our President, Viscount Nuffield, which enabled the Institution to open its Research Department at the beginning of January, 1939. Of the total, £24,000 has been invested in British and Canadian Government securities with fixed redemption dates, and £1,000 was placed at the disposal of the Research Committee for current expenditure

A separate income and expenditure account for the Research Department is submitted, but at this stage there is one combined balance sheet, on which the liabilities and assets of the Research Department for its first six months' working are clearly shown.

The Institution's Research Department.

It is with deep satisfaction that the Council are able to record the successful outcome of their plans for the establishment of the Research Department of the Institution with a laboratory at Loughborough College in the charge of Dr. George Schlesinger as Director of Research. The first report of the Research Committee is submitted with this report.

A Higher National Certificate in Production Engineering.

In our last Annual Report it was mentioned that a claim for a National Certificate in Production Engineering had been presented

to the Board of Education. It was in December, 1937, that Lord Nuffield and Lord Sempill waited on the President of the Board in connection with the claim. The subsequent negotiations have been long and difficult, but here, also, a successful outcome has to be recorded, for agreement in principle has been arrived at between our Institution, the Institution of Mechanical Engineers, and the Board of Education in favour of the establishment of a Higher National Certificate in Production Engineering. It would be difficult to stress too strongly the value and importance of this decision. Unfortunately, owing to the war, the coming into operation of the new Certificate will be delayed.

Awards.

The medal for the best paper by a member last session has been awarded to Mr. C. W. Leng, A.M.I.P.E., London Section, for his paper on "Spot Welding."

For the best paper by a non-member, the medal has been awarded to Mr. E. R. Gadd, M.Inst.Met., for his paper on "Heat Treatment of Materials."

The Hutchinson Memorial Medal, for the best paper by a Graduate, has gone to Mr. C. K. Hughes, London Graduate Section, for his paper on "Factory Organisation in Germany."

The winner of the Lord Austin Prize, for the highest attainments at the 1939 Graduateship Examination, was Mr. R. W. Marston, Leeds.

Thanks to Lecturers.

Once again the Council extend their cordial thanks to all those who gave lectures before the various Local Sections of the Institution last session. All reports indicate that the session was a very successful one and that aggregate attendances reached new record levels in many centres.

New Section at Nottingham.

A new Local Section was opened at Nottingham in December, with Mr. H. J. Gibbons as Section President. Lord Sempill presided at the Inaugural Meeting and the report of the proceedings which appeared in the *Journal* in January, 1939, has been reprinted in leaflet form, as Lord Sempill's speech formed an important contribution to the definition of the Institution's aims and objects, as well as giving a brief but clear account of its activities. The new Nottingham Section has made a most successful start.

Social Gatherings.

The various social functions arranged by the Institution and its Local Sections continue to expand and to become of increasing

interest. Annual Section Dinners are now held by most Sections. At the Sheffield Section Annual Dinner this year the principal speaker was Lord Riverdale, chairman of the Department of Scientific and Industrial Research.

Institution Visit to Canada and U.S.A.

An Institution Visit to Canada and the United States of America had been arranged for the autumn and would have attracted a party of about 40. The itinerary was to have included three days in Cleveland for the American Machine Tool Exhibition, and visits to Montreal, Toronto, Lansing, Washington, Detroit, and, of course, New York and its World's Fair. The war has prevented the visit being carried out, but it is hoped that it has only been postponed to happier times.

Regional Conferences.

The practice of holding Regional Conferences has proved very successful and is to be continued when circumstances permit. The Conferences (which are composed in each area of as many members of Local Section Committees as can attend) afford an excellent opportunity for discussing the main current interests and activities of the Institution. It is proposed to add to the number a Western Regional Conference representative of the Cornish and Western Sections, though these will continue to be summoned as well to the Southern Regional Conference, which meets at Headquarters.

Section Hon. Secretaries.

Section officers who retire this autumn after having served the Institution well in the capactity of Hon. Secretaries of Local Sections are : Mr. N. A. Cullin, B.A., Grad. I.P.E., Leicester Section, who has held office since 1934 ; Mr. E. Holden, A.I.P.E., Yorkshire Section, who is being succeeded by Mr. W. Hirst ; and Mr. J. B. Webster, Eastern Counties Section, who is succeeded by Mr. D. Braid. The Council extend to them grateful thanks for their work on behalf of the Institution, also to Mr. A. W. Buckland, A.M.I.P.E., Hon. Secretary, Coventry Section, who has joined H.M. Forces.

Standardisation.

The work of the Institution's Standards Committee has continued satisfactorily during the year, increased activity having been shown in numerous directions. In addition to the large number of members already representing the Institution on Technical Committees of the B.S.I., the following were added during the year to sub-committees dealing with the subjects indicated —

Mr. H. J. Copping—Grinding Wheels.
Mr. F. Williams and Mr. P. Holmes—Cranes.
Mr. F. Southwell—Personal Safety Equipment.
Mr. G. W. Clarke—Coupling Guards for Machinery.
Mr. J. G. Young and Mr. I. H. Wright—Lathe Centres.
Mr. C. A. Clarke—Twist Drills.
Capt. Burgoine—Welding of Thin Metal Sheet.
Mr. F. Siddall—Welding of Non-Ferrous Metals.
Mr. R. Broomhead—Bright Bolt and Nuts.
Mr. L. W. Jukes—Calibration of Testing Machines.
Mr. H. D. S. Burgess—Drawing Office Practice.

The subjects dealt with by other technical sub-committees on which reports were submitted from time to time by our representatives serving on them included the following :—

Grinding Machine Spindles ; Pointers for Dial Instruments ; Saws ; Precision Tools ; Taps and Dies ; Goggles ; Storage Bins and Racks ; Splines and Serrations ; Pipe Threads ; Cast Iron Straightedges ; Travelling Electric Cranes ; Screw Threads ; Jig Bushes ; and many other subjects.

The range of activity represented by this important work carried out by so many of our members—all on a voluntary basis—is very great, and the Council and the Standards Committee desire to make due acknowledgements to all concerned. In particular they desire to place on record their thanks to Mr. J. E. Baty for his work as chairman of the Precision Tools Committee of the B.S.I. and as a member of several other precision engineering committees of that body.

The opening of the Research Department of the Institution in January, 1939, enabled the Standards Committee to hand over to that Department the question of preparing Acceptance Test Charts for Machine Tools, and the subject is dealt with in the First Report of the Research Committee.

Mr. S. J. Harley has been added to the Standards Committee during the year.

RESEARCH DEPARTMENT.

FIRST REPORT OF THE RESEARCH COMMITTEE, 30 JUNE, 1939

Part I—Introduction.

Opening of the Department.

THE Research Department of the Institution was opened at the beginning of January, 1939, when commodious laboratory premises at Loughborough College were formally handed over by Dr. Herbert Schofield, M.B.E., Principal, for the use of the Institution. Dr. Schofield was acting on behalf of the Board of Governors of the College, who had generously agreed to place the premises free of charge at the Institution's disposal. At the same time Dr. George Schlesinger took up duty as Director of the Department.

Viscount Nuffield's Gift.

The decision to commence the work of research had been made possible by the munificence of the President of the Institution, Viscount Nuffield, who, at the Annual Dinner on October 21, 1938, had announced that he proposed to give the Institution £25,000 to enable it to proceed with its research plans and engage the services of Dr. Schlesinger.

The First Plans, 1936.

It was in January, 1936, that the proposal to establish a Research Department originated. Dr. Schlesinger had come from Brussels to give the Institution his lecture on "Machine Tool Tests and Alignments." It was then learnt that he would be free to settle in this country. Arrangements were made for him to visit Loughborough College, Dr. Schofield having received favourably the suggestion that a research laboratory organised by the Institution, with Dr. Schlesinger as its Director, should be established there.

Report from the Examinations Committee.

When the Examinations Committee met on May 27, 1936, it had before it a preliminary draft Report on the subject, together with a memorandum from Dr. Schlesinger, dated May 7. These documents were sent forward to the meeting of the Council of the Institution at Sheffield on June 20. They were approved, and Lord Sempill, President, Mr. J. H. Bingham, Chairman of Council, and

Mr. J. W. Berry, Chairman of the Examinations Committee and Joint Examinations Board, were appointed "to make inquiries as to the possibilities of financing a scheme of the kind proposed."

Section Committees Consulted.

Having considered a revised memorandum from Dr. Schlesinger, dated November 17, the Council on December 12, 1936, directed the Development Committee to consult Local Section Committees on the subject. In March, 1937, the Council received the reports from the Local Section Committees, all but two of which were in favour of proceeding with the plans.

Lord Austin's Speech.

It was not till October, 1937, however, that any further developments took place. In that month the Examinations Committee presented another report, and in his speech at the Annual Dinner on October 29, Lord Austin, Past-President, referred to the proposals in favourable terms. This was the first public reference to the scheme, and the interest it aroused, inside and outside the Institution, was considerable.

Special Committee Appointed.

On December 7, 1937, the Council set up a Special Committee on Research to prepare detailed plans. Mr. J. H. Bingham was elected its Chairman. The Special Committee's report, dated February 18, 1938, laid down the main lines which have since been adopted for the framework of the Research Department. The nearest model was the Research Department of the Institution of Automobile Engineers, and provisions from its constitution have been made use of where this seemed to be desirable.

The Institution of Mechanical Engineers Invited to Co-operate.

At its meeting at Manchester on March 12, 1938, the Council of the Institution decided to invite the co-operation of the Institution of Mechanical Engineers. As a result, a Standing Joint Committee on Research, representative equally of both Institutions, has been set up, and held its first meeting on March 15, 1939. The President of the Institution of Mechanical Engineers, Mr. E. Bruce Ball, is the Chairman of the Standing Joint Committee. Mr. H. C. Armitage, Vice-Chairman, is one of this Institution's founders. He is also chairman of the Department's Executive Committee.

Standing Research Committee Appointed.

The Special Committee, at the request of the Council, continued to function after the Department was opened, and remained in

control of research until June, 1939, when it was replaced by this Committee, of which Mr. Bingham has also been elected Chairman.

Composition of the Standing Committee.

The Council of the Institution hope that when all the nominations have been received, the composition of the Research Committee will be as follows :—

(*a*) The President, Deputy-President, and Chairman of Council of the Institution, *ex-officio* members.

(*b*) Ten members of the Institution elected by the Council : Messrs. H. C. Armitage, J. E. Baty, J. W. Berry, J. H. Bingham, H. D. S. Burgess, T. Fraser, G. H. Hales, J. D. Scaife, M. H. Taylor, and T. Thornycroft have been elected.

(*c*) Six representatives to be nominated by over 70 British firms or companies affiliated to the Institution. The first nominations are expected to be made in October, 1939.

(*d*) One representative each to be nominated by the following :

The Department of Scientific and Industrial Research.—Dr. S. L. Smith, Superintendent of the Engineering Department of the National Physical Laboratory, has been nominated and elected.

The Institution of Mechanical Engineers.—Mr. J. M. Newton has been nominated and elected.

The Board of Governors of Loughborough College.—Dr. Herbert Schofield, M.B.E., Principal of the College, has been nominated and elected.

The Board of Education.—Dr. W. Abbott, H.M. Inspector, has been nominated and elected.

The Board of Trade.—No nomination yet received.

The Machine Tool Trades Association.—No nomination yet received.

The Association of Technical Institutions.—No nomination yet received.

The Standing Committee's Terms of Reference.

The Council of the Institution have adopted Terms of Reference for the Committee, and these have been sent to the various bodies invited to co-operate.

Finance.

At this early stage the main factor in the financing of its Research Department by the Institution has been the gift of £25,000 from Lord Nuffield. Of this gift, £1,000 has been allocated to the Research Committee for current revenue purposes. The remaining £24,000 has been invested. The interest on the investments will be devoted to research.

The other sources of income of the Research Department will include :—

(*a*) Transfer to the Research Committee of 80% of all membership subscriptions paid to the Institution by its Affiliated Firms.

(*b*) Contributions for research received from all sources.

(*c*) Fees earned by the Department for work done.

(*d*) Grants from Institution funds.

(*e*) Grants received from other sources.

It is not possible at present to estimate revenue for any length of time ahead, but from the above sources it was expected that the Research Department could rely for the financial year 1939-40 on an income of over £2,200. This estimate, unfortunately, will have to be revised because of the war. No appeal for funds has yet been issued by the Council of the Institution. The Council's view, which is shared by this Committee, is that before a formal appeal for funds is issued it is desirable to give concrete evidence to the engineering industries of the country as to what is covered by research in production engineering.

Research to be Concerned with Productive Methods, not Products.

One may speak of the electrical engineering industry, the aeronautical engineering industry, the machine tool industry, the automobile engineering industry, and of many other industries, but one cannot speak of a production engineering industry, for there cannot be such a thing. Production engineering is a science—a relatively new science—which is at the service of all the engineering industries, and many others, though some of them, even now, are slow to take advantage of it or to employ its practitioners. It is the science of economic engineering manufacture, concerned principally with productive methods—not products.

Position Compared with Other Research Organisations.

On the other hand, the many Research Associations so far formed that receive financial support from the Department of Scientific and Industrial Research, and that are dealt with in its current Annual Report, are concerned directly either with specific products or processes bearing on specific products—in effect, with particular industries. Whether they deal with cast iron or coal, linen or laundering, pottery, paint, or printing, it is appropriate that these Research Associations should be organised, financed, and controlled by whatever industry they serve. Production engineering research is in an altogether different position. There is no one industry that could be made responsible for it, important though it is likely to be to the national economy. If this Institution had not undertaken the task, it would have been left unattempted.

Machine Tool Research from the User's Point of View.

It is sometimes said, quite wrongly, that production engineering research is synonomous with research into machine tools. The number of production engineers engaged in the machine tool industry is small compared with the total number engaged in all other engineering industries. Most production engineers, it is true, are necessarily concerned with machine tools, but *as users and not as makers*. Any research in machine tools by this Institution will be undertaken primarily from the point of view of the user, not that of the maker, through the closest co-operation of both on research matters is plainly desirable. The distinction between user and maker is important. It applies widely, and not only in the case of the machine tool industry. The Institution cannot, therefore, restrict the activities of its Research Department to any single industry. Its aim, rather, is to benefit all British engineering industries by promoting research that will help the production engineer to develop and improve manufacturing technique and methods generally.

A Great Gesture by a Great Man.

There is an old saying that "what is everybody's business is nobody's business," and the fact that so many industries are concerned with the problems which production engineering research embraces may make its early stages more difficult to finance on an adequate scale than if one industry only were concerned. The vision shown by our President, Lord Nuffield, in giving the Institution £25,000, has made possible a start this year. It was a great gesture by a great man, designed to help a young science, the development of which, as he so clearly sees, must profoundly influence the future industrial efficiency of Britain. It will be the task of this Institution so to conduct its research that before long our engineering industries will see the necessity for it just as clearly as Lord Nuffield. They can rely on one important factor—that the findings of this research, if of practical value, will not be pigeon-holed, but put into practical operation. The members of the Institution, unquestionably, will see to that.

Part II—Work in Hand.

Summary of Preliminary Programme.

As soon as it was decided to open the Research Department, the Special Committee on Research set up an Organisation Committee, of which Mr. H. C. Armitage became chairman, and the other members of which were Mr. J. D. Scaife, Mr. J. E. Baty, Mr. Mark Taylor, with Mr. Bingham *ex-officio* as chairman of the

Special Committee. The Standing Committee has since re-appointed the same Committee as the Executive Committee.

After full consideration it was decided that the first tasks of the Research Department should be the preparation of Acceptance Test Charts for Machine Tools and an investigation into the possibilities of standardising Surface Finish. Other subjects which the Standing Committee have been urged to take up for investigation are: the relative advantages of grinding and scraping as methods of finishing surfaces; materials and tools used in the cold forming of parts; and cutting fluids. The question of cutting tools has been amongst other subjects discussed by the Standing Joint Committee on Research with the Institution of Mechanical Engineers. The Research Department has also been requested to undertake certain investigations for individual companies, but in only two cases has it been possible to agree to the request. Fees will be charged for any work done for individual companies.

Handicaps—and Help.

At this stage the work to be undertaken is strictly limited by the finance available. It has not yet been possible to provide the Director of the Research Department with a technical assistant or to purchase for the laboratory at Loughborough more than a small fraction of the equipment urgently required. It will take time to overcome these deficiencies. Meanwhile the thanks of the Institution are due to a member of this Committee, Mr. Baty, who has kindly presented to the laboratory four (test) gauges and a dial test indicator stand. Thanks are also due to Messrs. Taylor, Taylor and Hobson, Leicester, for the loan of an autocollimator, and of the Contorograph designed by Mr. Harry Shaw, Grad.I.P.E.; to Messrs. Alfred Herbert, Ltd., for the loan of the surface tester of Schmaltz-Zeiss; to Loughborough College which has loaned a lathe, a tool grinder, a drilling machine and other laboratory requirements; to Messrs. Charles Churchill & Co. Ltd., for the loan of a metaphot; and to Messrs. Gaston E. Marbaix, Ltd., for the loan of a profilometer.

The First Important Task: Acceptance Test Charts for Machine Tools.

Since 1934, acting in the interests of the users of machine tools, the Institution has been pressing for British Standards for acceptance tests and alignments for machine tools. The Standards Committee of the Institution returned again and again to the subject. The response to a questionnaire issued to members in 1936 showed that 100% of those who answered were in favour of standardisation. In 1937, Mr. H. C. Armitage, who, up to that time, had been a member of the Council of the Institution since its foundation in

1921, tested out 300 new machine tools (mostly British) against Schlesinger tests.

Advantage was gladly taken of this valuable experience, and of Dr. Schlesinger's appointment as Director of Research, when it was decided that the first major task of the Department should be the preparation of acceptance test charts for machine tools.

It was hoped that closer examination of the whole subject would show that the obstacles that had prevented approval of the principle of establishing British standard acceptance tests were capable of being smoothed out. It was felt that the best way to achieve this would be to go ahead with the preparation of acceptance test charts which might serve as the basis for British standards, if agreement on that issue could be achieved. It would always be open to the Institution, either alone or in collaboration with other interested organisations, to publish the acceptance test charts as Institution of Production Engineers Standards and invite members of the Institution and others to make practical use of them when ordering and testing machine tools.

The work of preparing the charts was therefore begun in the earliest days after the opening of the Research Department and the first part of the task has been completed, covering acceptance test charts for the following machines :—

Centre lathes. Horizontal Milling machines. Vertical Milling machines. Plain (slab) Milling machines. External grinders. Radial drills.

To go with the charts there has also been prepared a brochure covering the following ground :—

I.—Historical survey. II.—General instructions. III.—Notes on the application of tests. IV.—Measuring tools and methods employed. V.—Amount and direction of tolerances.

" The basis on which the charts have been prepared is that of codifying a standard of acceptance after the machine tool has been fixed in the user's workshop. . . . They are not intended for the practical use of the builder of machine tools except for the purpose of giving him a guide and a standard for reference in cases of dispute. . . . The test sheets have been designed in a form which makes them available for instant practical use, and it is only necessary to hand them over to a competent inspector to obtain the advantages that will accrue from the knowledge that the machine tool is of an accuracy that production engineers can justly call for and have every confidence in the work that will be produced." *—extract from the brochure.*

It was fully expected that it would have been possible to secure the support of the Machine Tool Trades Association for the proposals. That Association appointed an influential delegation to attend a Conference with us and with representatives of the Institution of

Mechanical Engineers who sit on our Standing Joint Committee with that body. A date had been fixed for the Conference at our Headquarters—September 13—but the outbreak of war has compelled a postponement of plans to press forward with our proposals at this stage. As soon as circumstances allow, however, they will be actively promoted.

The Second Important Task—Surface Finish.

The equipment necessary for research on surface finish having been procured on loan, and the co-operation of many affiliated companies having been secured towards the provision of samples and information, it is proposed that the Director of Research shall continue to carry on the work of research on surface finish, notwithstanding the outbreak of war.